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Spatial Welfare Impacts of a Grain Ethanol Plant

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This study inquires into the spatial welfare impacts of a grain ethanol plant established in an area with a beef feeding industry. Corn producers will benefit, but by how much? Why do plants seem to price their animal feed byproduct so low that beef producers may benefit from lower feed costs, despite the higher corn price? Why do ethanol plants in some areas dry all their byproduct feed while in other areas plants sell it all in wet form? How are these outcomes affected by the density of corn production, by the density of feedlots, and by the size of the ethanol plant?

The answers to these questions are important to the agents affected, but empirical evidence is not available on a sufficiently fine spatial grid to address them. Therefore the approach of this study is to construct a spatial equilibrium model to examine conditions that determine the distribution of welfare benefits from the existence of a plant. The model is driven by the plant's choice of prices for corn and byproduct so as to minimize net feedstock cost for the plant's capacity. These prices, and the welfare impacts on corn producers, feedlots and the plant itself, will depend upon transportation costs, the density of corn and beef production and the size of the plant.

Related Literature

At least two published studies have looked at the effect ethanol plants have on local corn prices and markets, but no studies as yet have considered the effect of an ethanol plant on the spatial interaction between corn and byproduct prices. Gallagher, Wisner and Brubacker (2005) examined spatially distributed price data to determine whether prices tended to be set at the plant or on a delivered basis. Using regression analysis with spatial coordinate variables, they found prices near most of the plants conformed to delivery-point pricing. McNew and Griffith (2005) examined corn prices from spatially located pricing points in the midwest over a number of years, including areas where ethanol plants opened during the period. Their econometric estimate was that an ethanol plant increased corn price by $0.125/bushel at the plant, and corn prices were affected up to 68 miles away.

Careful mathematical modeling of spatial equilibrium prices dates back at least to the 1929 article by Hotelling. Since then, many models have been developed which can be characterized as being continuous or discrete in nature. Continuous spatial analyses typically assume continuous, uniform space and use generalized market functions with the intent of inferring general spatial relationships using economic theory. Some modern proponents of this approach include Greenhut and Ohta (1975) and Beckman (1985). Its founders include Hotelling (1929), Laoucsh (1954) and Von Thünen (Hall 1966). Discrete models are more empirically oriented, usually employing mathematical programming to identify and characterize equilibrium or optimum outcomes, using real world data at discrete points. This approach has been extensively exploited by Takayama and Judge (1971). The primary intent of this approach is often to provide numeric answers to specific questions, situations or for certain industries.

Some researchers have blended the continuous and discreet approaches. Mwanaumo, Masters and Preckel (1997) analyzed Zambia's maize markets in response to trade liberalization. Using a Takayama and Judge programming framework but assuming uniform, continuous space they used general pre-reform data to analyze equilibrium changes, with both market-to-market and farm-to-market transportation costs. They were preceded by Gersovitz (1989) who, using linear programming, also integrated over continuous space using a constant-elasticity function to examine the spatial effects of policy interventions. These researchers consider interactions between single prices and products. In our case of ethanol plants, prices of two related goods are involved, and in this case, aggregation using linear transportation costs is intractable. Hence, we develop a continuous model to approximate spatial effects of an ethanol plant.

The Spatial Equilibrium Model

Our spatial equilibrium model chooses prices for corn and byproduct so as to minimize the net feedstock cost to run the plant at capacity. The explicit constrained minimization problem is expressed later in equation (1), after we derive equations describing various components of the constraints. In this model, the ethanol plant is located on a plane on which corn and beef is produced at fixed densities uniformly over the plane. The plant offers a price premium for corn sufficient to attract enough corn (by offsetting transportation costs) to run at full capacity. A comparable amount of wet byproduct is produced and priced at the plant so that all of it is sold to feedlots.

Wet byproduct (WDGS - wet distillers grains and solubles) has water removed with centrifugal or similar low-cost techniques, whereas DDGS (dry DGS) requires expensive thermal drying. The plant can thus afford to set the FOB plant price of WDGS, per pound of dry matter (DM), lower than the price of DDGS. WDGS, on the other hand, has higher feed value than DDGS for fattening cattle (Perrin and Klopfenstein 2000). Because of the amount of water in WDGS, transportation costs loom high in limiting sales. By increasing its corn prices the plant can attract corn supply from farther out and encourage greater substitution of byproduct for corn in local beef rations.

Following the Takayama-Judge models of spatial monopoly (Takayama and Judge 1971, 208) and multi-product equilibrium (Takayama and Judge 1971, 235), the economic spatial analysis here is a programming model in which the ethanol plant chooses FOB prices for corn and byproduct to minimize its net cost of feedstock, *i.e.* the amount paid for corn minus the amount received for byproduct. The model differs from the Takayama-Judge monopolistic model in that the objective function is cost, rather than profit, and it differs from their multi-product models in that we consider the demand for two substitutable inputs (corn and wet byproduct.) Unlike Takayama and Judge (more discrete) spatial models, the model assumes constant, uniform distributions of corn producers and byproduct consumers who interact with each other and/or the ethanol plant.

Demand for the plant's WDGS is determined from the number of animals being fattened in the area, and the optimal combination of corn and WDGS per pound of beef produced. Cattle feeders choose the minimum-cost ration using a unit isoquant that we estimate as a part of this study, based on the prices they face at their particular distance from the plant. Corn production in the area is thus divided between the ethanol plant and the feedlots, depending on both the price of corn and the price of byproduct set at the plant.

The objective function of the ethanol plant is:

$$\text{(1)} \quad \begin{aligned} &\min C = P_c * U - P_b * V \\ &subj.\ to: \\ &U = Q_{cs} - Q_{cd} \\ &V = Q_{bd} \end{aligned}$$

where:

C Ethanol plant net feedstock costs ($/year)

P_c CIF price of corn at plant ($/ton of DM)

P_b FOB price of byproduct at plant ($/ton of DM)

U Quantity of corn required by plant for full capacity (DM tons/yr)

V Quantity of byproducts produced by plant at full capacity (DM tons/yr)

Q_{cs} Quantity of corn supplied (DM tons/yr)

Q_{cd} Quantity of corn demanded by beef producers (DM tons/yr)

Q_{bd} Quantity byproduct demanded by beef producers (DM tons/yr)

Transportation costs

To derive total quantities supplied and demanded, transportation costs must be taken into account. The price faced by a corn producer located *r* miles from the plant is:

(2) $P_{cr}(P_c, r) = P_c - T_c r,$

but for tractability in computations, we approximate this transportation cost with an exponential expression

(3)
$$P_{cr}(P_c, T_c, r) \cong P_c \exp(rt_c), \quad \textit{where} \quad t_c = [\sum_{r=1}^{50} (1/r) \ln(1 - \frac{T_c}{P_c} r)] / 50,$$

that is, t_c is the average transportation rate, over r=1 to 50, of the values of t_c that set $\exp(rt_c)$=[1-(T_c/P_c)r] . The delivered price of wet byproducts increases with distance from the ethanol plant, and is approximated similarly as

(4)
$$P_{br}(P_b, T_b, r) \cong P_b \exp(rt_b), \quad \textit{where} \quad t_b = [\sum_{r=1}^{50} (1/r) \ln(1 + \frac{T_b}{P_b} r)] / 50 \ .$$

Baseline values of transportation costs are based on \$3/loaded mile for a 25-ton load, yielding T_c=\$0.14/ton DM/loaded mile or t_c=\$0.00112, and T_b=\$0.34/ton DM/loaded mile or t_b= \$0.00291.

Quantities of corn and byproduct demanded per pound of beef produced

Corn and byproduct quantities demanded per pound of beef produced can be determined from a beef unit isoquant. This isoquant is based on production relationships published by the UNL Department of Animal Science (Buckner et. Al, 2007). We used those relationships to generate combinations of corn and WDGS needed to produce one pound of beef in the feedlot. We then estimated the following isoquant from those data (VanWart, p 75):

(5) $q_b=6.859-1.593q_c+0.083(q_c)^2$,

where q_b and q_c are dryweight pounds of byproduct and corn, respectively, per pound of beef produced. The least-cost ration, at distance *r* from the plant, is found by minimizing cost per pound of beef, and can be expressed as:

$$(6)\quad \begin{aligned} &q_c(P_c,P_b,r)=9.56-6.00(P_{cr}/P_{br}), \quad \text{and} \\ &q_b(P_c,P_b,r)=-0.76+3.00(P_{cr}/P_{br})^2. \end{aligned}$$

Total quantities of corn and byproduct demanded by beef producers can now be calculated as quantity demanded per pound of beef produced, times beef density *Z*, across the area out to the trading borders for corn (R_c) and byproduct (R_b), or

$$(7)\quad \begin{aligned} Q_{bd} &= 2\pi Z\int_0^{R_b} rq_b(P_c,P_b,r)dr, \\ Q_{cd} &= 2\pi Z\int_0^{R_c} rq_c(P_c,P_b,r)dr. \end{aligned}$$

Quantity of corn supplied and the corn trade radius

For this analysis, we assume that at every point on the plane corn production occurs at the density of q_{cs} tons per square mile, and that corn producers may sell their grain for an outside price of P_c^o. Corn producers at distance r from the plant will ship corn to the plant if plant price minus transportation (P_{cr}) is at least equal to P_c^o. The radius out to the border at which this occurs, R_c, can be determined by solving equation (3) for r, which yields:

$$(8)\quad R_c(P_c^0, P_c, t_c) = \frac{1}{t_c}\ln\left(\frac{P_c^0}{P_c}\right)$$

Total corn supplied to the plant and to feedlots within the corn border is the production density times the area within the corn supply market border, or:

$$(9)\quad Q_{cs}(q_{cs}, t_c, P_c^o, P_c) = q_{cs}\pi R_c^2 = q_{cs}\pi\left[\frac{1}{t_c}\ln\left(\frac{P_c^o}{P_c}\right)\right]^2$$

By choosing the corn price P_c, the plant will change the corn supply market border, R_c, and thus change the amount of corn attracted to the plant.

Quantity of byproduct demanded and the byproduct trade radius

There exists a comparable radius, given particular price ratios, where 0 byproducts are demanded. From equation (6), demand for byproducts equals zero when the price ratio is .503, and inserting this price ratio into equation (4) and solving for r yields the byproduct trading radius

$$(10)\quad R_b = \frac{1}{t_c - t_b}\ln(.503\frac{P_b}{P_c}).$$

If this border occurs outside of the corn supply market border, P_c would be changed to the outside price P_c^o with no transportation gradient, so the border radius becomes

$$(11)\quad R_b^o = \frac{1}{-t_b}\ln(.503\frac{P_b}{P_c^o}).$$

The smaller of R_b or R_b^o will be used for the byproduct demand market border. In the solution algorithm, both borders will be simultaneously solved for at the price ratio for a given iteration and the smaller one used to evaluate whether this price ratio achieves an optimum or, if not, to evaluate the gradient for the next iteration.

Now that Q_{cs}, Q_{bd}, and Q_{cd} have been calculated, the programming problem can be solved. Substituting in equations above, the programming problem can be expressed as :

$$\min_{Pc,Pb} C = P_c U - P_b V$$

$$subj.\ to:$$

$$A).\quad U = \mathrm{q_{cs}}\pi\left[\frac{1}{t_c}\ln\left(\frac{P_c^o}{P_c}\right)\right]^2 - 2\pi Z\int_0^{\min\left(\frac{r_o}{2},\frac{\ln\left(0.50\frac{P_b}{P_c^o}\right)}{-2t_b}\right)} r\left(-\frac{b}{2c}+\frac{1}{2c}\left(\frac{P_c}{P_b}e^{r(t_c-t_b)}\right)\right)dr$$

(12)

$$-2\pi Z\int_{\min\left(\frac{r_o}{2},\frac{\ln\left(0.50\frac{P_b}{P_c^o}\right)}{-2t_b}\right)}^{\frac{1}{t_c}\ln\left(\frac{P_c^o}{P_c}\right)} r\left(-\frac{b}{2c}+\frac{1}{2c}\left(\frac{P_c}{P_b}e^{r(t_c-t_b)}\right)\right)dr$$

$$B).\quad V = 2\pi Z\int_0^{\min\left(\frac{r_o}{2},\frac{\ln\left(0.50\frac{P_b}{P_c^o}\right)}{-2t_b}\right)} r\left(\left(a-\frac{b^2}{4c}\right)+\frac{1}{4c}\left(\frac{P_c}{P_b}e^{r(t_c-t_b)}\right)^2\right)dr$$

Model Results – Baseline Case

The optimization problem specified in equation (12) was implemented in Microsoft Excel, using the Microsoft Excel Solver tool which uses the Generalized Reduced Gradient (GRG2) nonlinear optimization code and the simplex method for linear and integer problems. The basic spreadsheet model is available from the author.

Table 1 summarizes base values of parameters that will be evaluated using the optimization model. Corn quantities are expressed as 85% dry matter. In addition to the parameters listed, other important technical parameters include assumptions of 2.7 gallons of ethanol and 18 lbs of distillers' grains produced per bushel of corn.

The baseline solution of the model, with the spatial welfare impacts of the ethanol plant, is presented in Table 2 and Figure 1. The corn price premium at the plant necessary to attract the required quantity of corn is very small, only \$.04/bu (1.3% increase from the base corn price). The wet byproduct price necessary to dispose of all that was produced, expressed on a dry matter basis, was \$118.41/t, or on a dry matter basis about 93% of the price of corn at the plant. (This corresponds to observed ratios of 1.26 in 1999 as reported by Perrin and Klopfenstein, but 0.76 as reported in Waterbury, et al. in 2007.) The corn/byproduct price ratio at the plant caused the optimal inclusion rate there to be 47%, that is, byproduct constituted 47% of the feedlot concentrate diet (corn plus byproduct) on a dry matter basis. Beef producers next to the plant gain considerably from the existence of the plant, as the cheaper byproduct allows them to produce beef at a cost of \$0.36 per pound (for the concentrate portion of production costs), compared to \$0.39 at the previous corn price of \$3.00/bu.

Because these welfare impacts diminish with distance from the plant, we are interested in average welfare impacts across the trading area. To conceptualize the average corn price premium due to the plant, consider that the price surface over the trading area consists of a cone with height, $h = P_c - P_c^o$, tapering to zero at R_c (figure 2). The average corn price premium received is the average height of this cone, its volume divided by its base. We therefore represent the average price as

(13) $$\text{average price} = \frac{1}{3}\pi h R^2 / \pi R^2 = h/3,$$

where R represents the radius of trade. On the average, then, after deducting transportation costs, corn producers receive one third of the price premium offered at the plant, or $0.01/bu in our baseline scenario.

The spatial benefits for beef producers are more complicated, for two reasons. First, feedlots face rising prices for byproduct out to the byproduct trade border. The delivered price surface for byproduct is represented by an inverted cone. Using logic similar to that above, the average price paid is then $2h/3$, where h is the height of the edge of the inverted cone, or $h=P_b^R-P_b$, where P_b^R is the delivered price of byproduct at the border of the trading area. Secondly, they face falling prices for corn, but only out to the corn trading border, which in all cases considered here was a smaller radius than the byproduct border. Using the logic of equation (13) we determined that the price of byproduct falls less than half a cent per pound from the plant to the 12-mile corn trading radius, and drops less than another half a cent per pound at the 25-mile byproduct trading boundary where competition from the plant 50 miles away limits further byproduct sales. The average feed cost for all feedlots in the 25-mile radius is $0.361/lb (Table 2), a savings of 11.9% relative to the $0.41/lb for a corn-only ration at the outside price of P_c^o = $3.00/bu. Figure 2 illustrates how the optimal inclusion rate falls and the cost per pound rises, out to the 12-mile corn trading border, and on to the 25-mile byproduct border where byproduct sales end due to competition from another plant.

Model Results – Sensitivity Analysis

In order to determine how changes in the ethanol environment would affect the welfare of the agents, a sensitivity analysis was performed. In this analysis, one of five exogenous variables was varied while all others were held constant. Four of the exogenous variables, corn density, beef density, plant capacity and competition, were evaluated over the range of values identified in Table 3. The competition variable is a proxy for the competitive environment a plant would face when trying to sell its byproduct or attract corn. The competition variable assumes that all around the plant, a given distance away, there is an identical plant selling and requiring identical feedstock. The final exogenous variable examined was the drying of distillers grains, evaluating the base line scenario with a beef isoquant based on either a wet or dry distillers grain product.

Under average beef and corn densities in Nebraska, beef feedlots appear to be the primary beneficiaries of an ethanol plant, with feed cost per pound being lowered by about 12% (table 2). That benefit falls significantly as beef density increases, as ethanol plant size diminishes or as distance to the nearest competing ethanol plant increases (table 4). In fact, for beef densities of the highest observed in Nebraska counties, or for competing plants 200 miles from the local plant, average feedlot benefits disappear entirely. In these scenarios, the ethanol plant can price byproduct so high that feedlot feed costs remain at the $0.41/pound level that existed with no ethanol plant. Feedlot benefits increase as the size of the ethanol plant increases, reflecting the WDGS price reductions that larger plants find necessary to sell the larger output. Drying of byproduct to sell as DDGS, or changes in corn density, have little impact on feedlot benefits, at least at the baseline densities considered in this study.

Corn producers do not receive much benefit from the location of an individual plant, because in the model the plant can attract sufficient quantities of corn with a very small premium. At the base scenario, the plant increased average corn price by only 0.3%, and only with the very lowest corn densities would this benefit exceed a 1% boost in price, to $3.04. Other factors considered have essentially no impact on the corn price premium (table 5).

The sensitivity analysis for net ethanol feedstock costs per gallon of ethanol produced can be seen in table 6. Corn density has little affect because corn transportation costs are quite low relative to the corn price. Net feedstock costs fall significantly as beef density and distance to competing plants increase. Conversely, net feedstock costs increase significantly as plant size increases.

It is the ethanol entrepreneur who determines where and how a plant is located. Judging by the results displayed in table 6, the ethanol company would prefer a small plant selling DDGS, located in a high beef density environment as far as possible from competing plants. But this is misleading. The firm may prefer a WDGS plant if the lower drying cost offsets the higher net feedstock cost. It may prefer a larger plant if the scale economies offset the higher net feedstock cost. If the cost of drying byproduct were 6% or more of operating costs, this expense would more than offset the $0.033/gal reduction in net feedstock cost, making WDGS more attractive. (Total ethanol cost under circumstances considered here are in the vicinity of $0.55/gal for operating expenses, $0.25/gal for capital, plus feedstock cost of $0.75/gal, for a total of about $1.55/gal). Similarly, if economies of scale reduced operating and capital costs per gallon by 12% or more, a 100 mgy plant would be more attractive despite its having to pay an additional $0.20/gal for

Conclusions

This study simulated the impacts of an individual 50 million gallon per year ethanol plant on beef feedlots and corn producers. From a sensitivity analysis of the model results, it was found that within its market area, an ethanol plant would prefer little competition and dense beef production over also desirable dense corn production. Beef producers would prefer less dense beef production in the area, greater competition among ethanol plants, and ethanol plants of larger capacity. Plant and beef producer welfare are dependent on each other, but are inversely affected by most of the exogenous variables examined in this study. Greater beef density will benefit an ethanol plant, but increased competition among cattlemen for feed would diminish the benefits to beef producers.

Corn densities, at least for the range of densities examined, do not appear to significantly affect plant pricing. Beef density, however, will significantly affect plant pricing insofar as it allows plants to charge a higher price for their wet byproduct.

The impact of the aggregate ethanol industry on beef and corn producers is much greater than what has been examined in this study. Here we consider the impact of a single plant, which does not affect prices except in the local vicinity of the plant. This is because our interest is to explore how the benefits of a given plant are distributed among beef producers, corn producers and the plants. When hundreds of plants are opened, the national price of corn is bid up, as the recent expansion of the industry has demonstrated.

We rely in this study on estimates of the corn-byproduct trade-off in the production of a pound of beef in the feedlot. Extensive experimental data is available to support this relationship for byproduct inclusion rates up to 50%, but little experimental data is available to support our estimate of tradeoffs at inclusion rates above 50%, which occurred in the case of a 100mgy ethanol plant. Gains to feedlots would have been lower if inclusion rates had been restricted to 50% or so in this scenario.

This simulation model examines an artificial world in which corn production and cattle feedlots are uniformly distributed in the area, and both corn and byproduct are shipped directly to and from the plant as the crow flies. Thus we would not expect the specific results to occur, but the analysis nonetheless provides us with a better understanding of how various market participants might benefit, and what circumstances affect that benefit, than we are able to obtain in other ways.

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Figures and Tables:

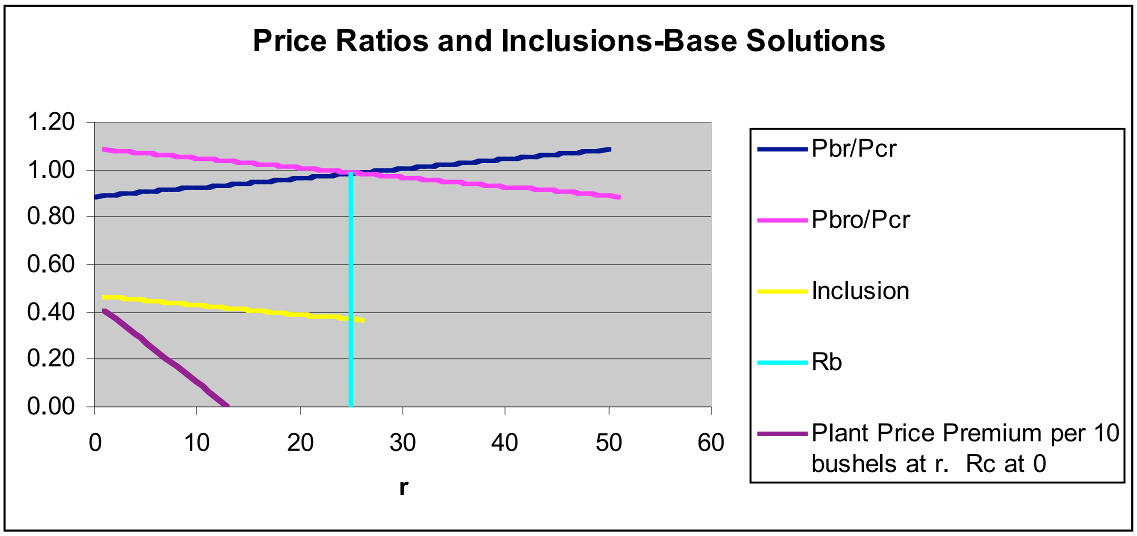

Figure 11: Graphic display of baseline solutions and borders

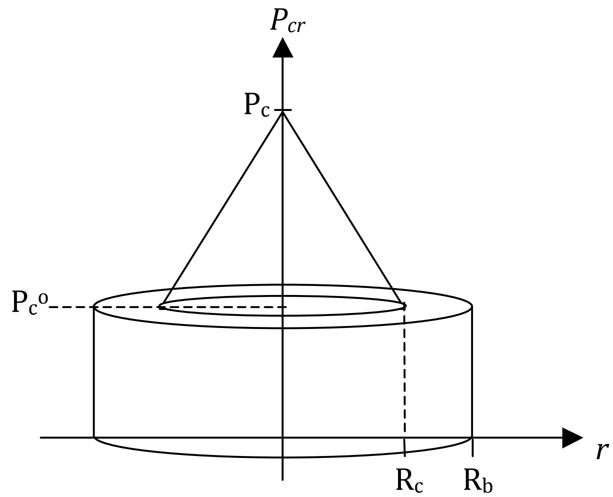

Figure 2: Corn Price Space Faced by Beef Producers Around the Ethanol Plant

Table 1: Baseline values for exogenous parameters

Parameters	Derived From	Value
P_c^o (Outside (US) corn price, \$/ton)	Border value of \$3/bu	\$126.05/ton
q_{cs} (corn density, tons/sq.mile)	Average corn production density in ethanol-relevant counties of NE[1].	1270 tons/sq.mi.
Z (beef production density, pounds/sq.mile)	Total beef produced in NE in 2005 (USDA 2007, *Meat Animals Prod.)* ÷ Total square miles in Nebraska (US Census 2007).	65,000 lbs/sq.mile (100 head fattened/sq.mi.)
T_b (Byproduct linear transport rate)	Calculated based on \$3/loaded mile for a 25 ton haul. Transport costs take DM content into account (35% for wet byproducts, 85% for corn).	\$.34/ton/loaded mile
T_c (Corn linear transport rate)		\$.14/ton/loaded mile
r_o (Distance to nearest competing plant)	Approximate average distance between plants in southeast NE[2]	50 miles
K (Ethanol plant capacity)	Average NE plant size of all 12 operating plants (rounded down to nearest hundred	50,000,000 gallons per year

Table 2. Estimated price and welfare impacts of a 50 mgy ethanol plant producing WDGS, baseline scenario.

		Location of plant impact		
Type of impact	Pre-impact value	At the plant	Average over the trade area	At the border of trade area
Corn purchase distance (mi)	-	0	0-12	12
Byproduct sales distance (mi)	-	0	0-25	25
Price of corn ($/bu)	3	3.04	3.014	3
Price ratio, byproduct to corn	-	0.927	0.981	1.007
Byproduct inclusion rate	-	0.47	0.41	0.379
Feed cost for beef gain ($/lb)	0.41	0.359	0.361	0.362
Net feedstock cost for ethanol ($/gal)	-	0.77	-	-
Beef cost relative to no plant, %		-12.40%	-11.90%	-11.70%
Corn price relative to no plant, %		1.30%	0.30%	0.00%

Table 3: Test parameter ranges and justification

Parameter	Lower Bound	Base	Upper Bound	Range as % of base	Justification
Corn Density (tons/sq.mile)	300	1270	1800	24-142%	These bounds are among the highest and lowest corn densities of eastern Nebraska counties (Johnson and Hamilton)
Beef Density (head/sq.mile)	45	100	450	45-450%	These bounds are among the highest and lowest beef densities of eastern Nebraska counties[3] (Douglas and Cuming)
Competition Proxy Location (miles)	30	50	200	60-400%	Except for the Hastings plants, all currently operating plants are no closer to each other than about 30 miles and are as far away as 200, for those in the panhandle.
Capacity (mgy)	25	50	100	50-200%	This range covers the smallest and largest currently operating plants in Nebraska.

Table 4: Sensitivity of average area beef production cost, $/lb.

Parameter	Lower	Base	Upper	%Change[4]
Corn Density: 300, 1270, 1800 tons/sq.mile	$0.37	$0.36	$0.36	-2.50%
Beef Density: 45, 100, 450 tons/sq.mile	$0.29	$0.36	$0.41	28.29%
Capacity: 25, 50, 100 mgy	$0.39	$0.36	$0.31	-25.81%
Competition: 25, 50, 200 miles from model's plant	$0.23	$0.36	$0.41	44.28%
Byproduct: WDGS, DDGS	*$0.36*		$0.35	-3.14%

Table 5: Sensitivity of average area corn price, $/bu.

Parameter	Lower	Base	Upper	%Change
Corn Density: 300, 1270, 1800 tons/sq.mile	3.04	3.014	3.01	-0.997%
Beef Density: 45, 100, 450 tons/sq.mile	3.01	3.014	3.03	0.660%
Capacity: 25, 50, 100 mgy	3.01	3.014	3.02	0.331%
Competition: 25, 50, 200 miles from model's plant	3.01	3.014	3.01	0.000%
Byproduct: WDGS, DDGS	3.01	3.014	$3.01	0.000%

Table 6: Sensitivity of net ethanol feedstock cost, $/gal.

Parameter	Lower	Base	Upper	%change
Corn Density: 300, 1270, 1800 tons/sq.mile	0.78	0.77	0.77	-1.30%
Beef Density: 45, 100, 450 tons/sq.mile	0.83	0.77	0.57	-45.61%
Capacity: 25, 50, 100 mgy	0.67	0.77	0.87	22.99%
Competition: 25, 50, 200 miles from model's plant	0.88	0.77	0.51	-72.55%
Byproduct: WDGS, DDGS		0.77	0.737	-4.48%